Hydrogen Showcase

Path to achieving net zero

@Cranfield University – 20/09/22

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Sustainability

Our story

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We need to take a comprehensive – a 360-degree – view on sustainability from every angle.

Our **DEGREE** framework sets clear priorities for Sustainability at Siemens

Decarbonization –
support the 1.5°C target to fight global warming

Employability –
enable our people to stay resilient and relevant in a permanently changing environment

Ethics –
foster a culture of trust, adhere to ethical standards and handle data with care

Equity –
foster diversity, inclusion, and community development to create a sense of belonging

Governance –
apply state-of-the-art systems for effective and responsible business conduct

Resource efficiency –
achieve circularity and dematerialization

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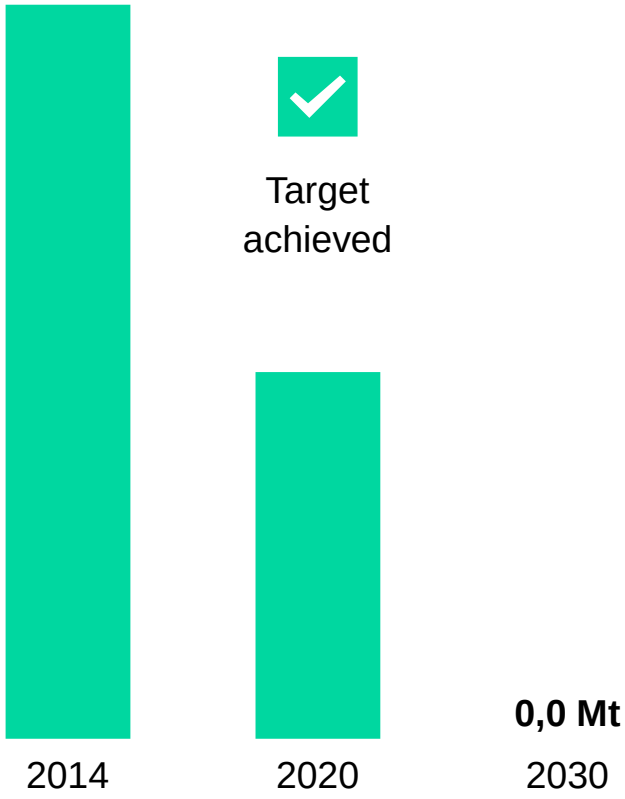
Deep dive Decarbonization – Net-Zero Operations: We achieved our interim target to half our CO_2 footprint by 2020 and are on track to become net-zero by 2030



1 **We reduced our CO_2 emissions by >50%** via energy efficient buildings & factories, green electricity, Decentralized Energy systems, new mobility concepts & eCars, reduction of SF6 gas

2 **Our investments in energy efficiency projects led to 15% reduced energy costs**

3 **E.g., >70% of the electricity consumption of our sites globally is covered by renewables**

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Supporting a roadmap of actions that need to be taken to become carbon-neutral by 2050

1 Electrification of transport & sustainable alternative fuels | **2** More sustainable production cycles

How commitment

Set a leading example on climate action internationally and will put pressure on to other players to make more ambitious moves towards decarbonization.

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Decarbonization

Technology developments

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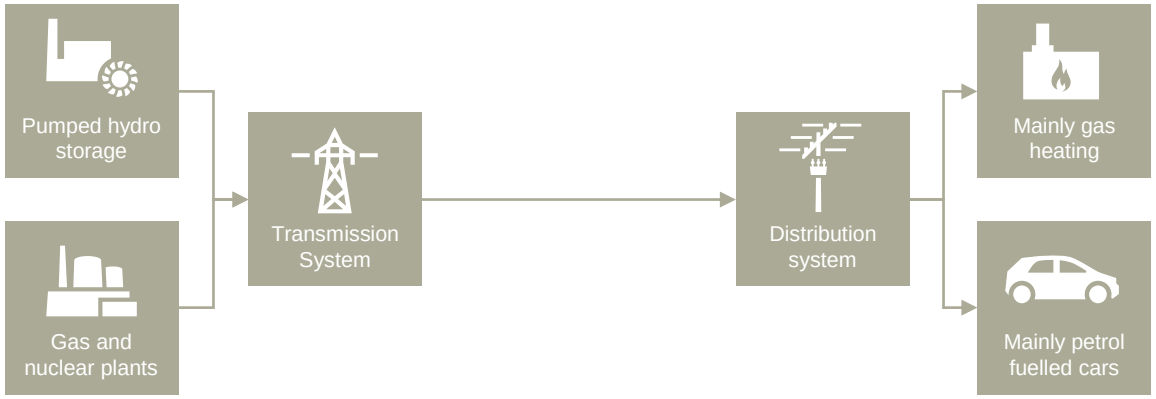
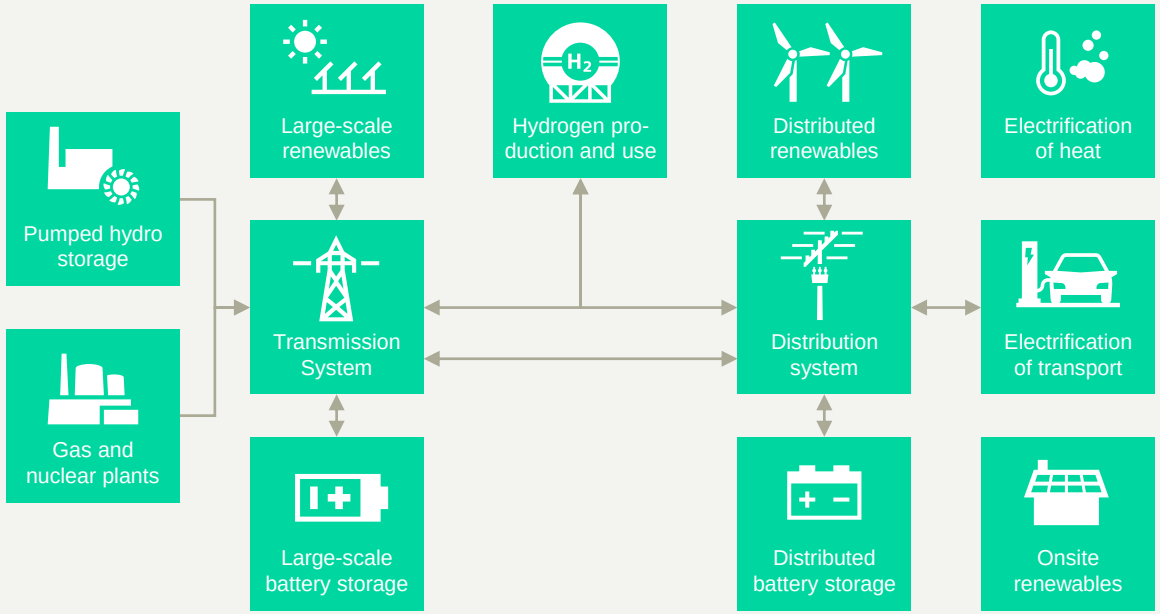
The transition from the “old” to the “new” energy system



- Centralized
- One way energy flows
- Carbon intensive
- Commodity sales

- Meter points
- Value is upstream
- Not digitalized



- Distributed
- Dynamic and flexible energy flows
- Low-carbon
- Service-oriented

- Customer-centric
- Value is downstream
- Digitalized and data-driven

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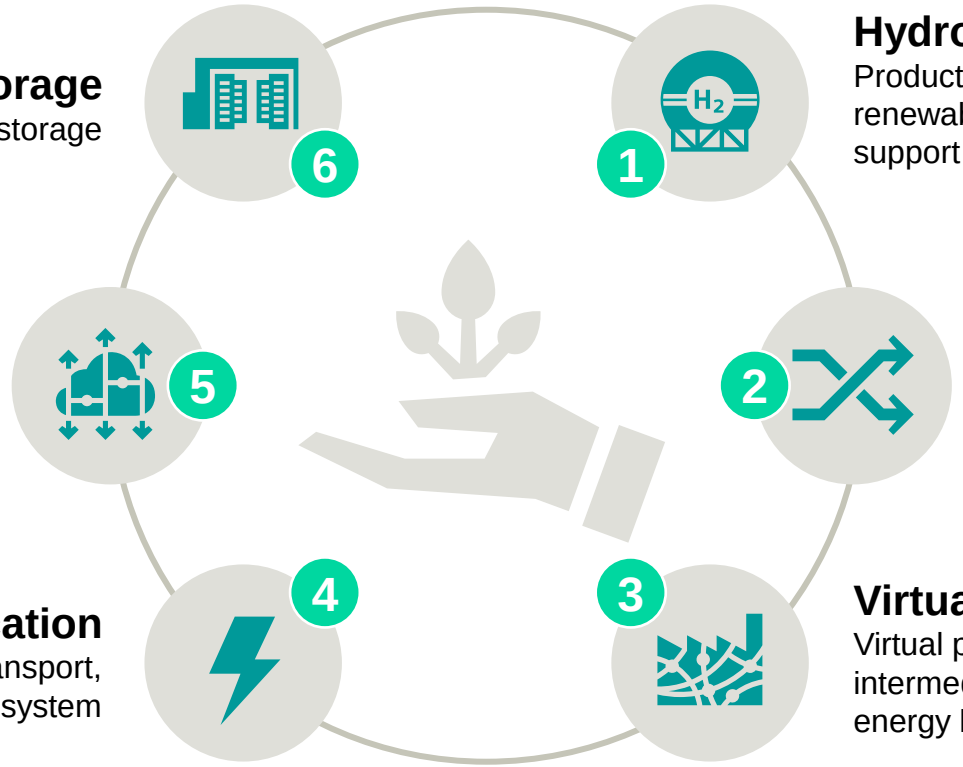
Technology developments that integrate and stabilize power output from renewable systems

Storage
Reducing costs of battery storage

Digitalization
Digitalization increasing the viability of using green and distributed technologies, giving more control over customer energy use, and enabling the emergence of new business models and energy services

Electrification
The move towards electrification of heat and transport, that adds further flexible electrical loads in the system



Hydrogen
Production of hydrogen using excess electricity from renewable energy resources gaining increasingly more support in the decarbonization agenda

Demand flexibility
The emergence of grid interactive smart that interact with smart grids to

1. Reduce overall consumption from fossil fuels
2. Provide grid stability through changing their energy loads via new technology
3. Generate revenue for selling energy demand or generation onsite that is flexible

Virtual power plant
Virtual power plants are platforms that act as intermediaries between consumers, who have flexible energy loads and network operators

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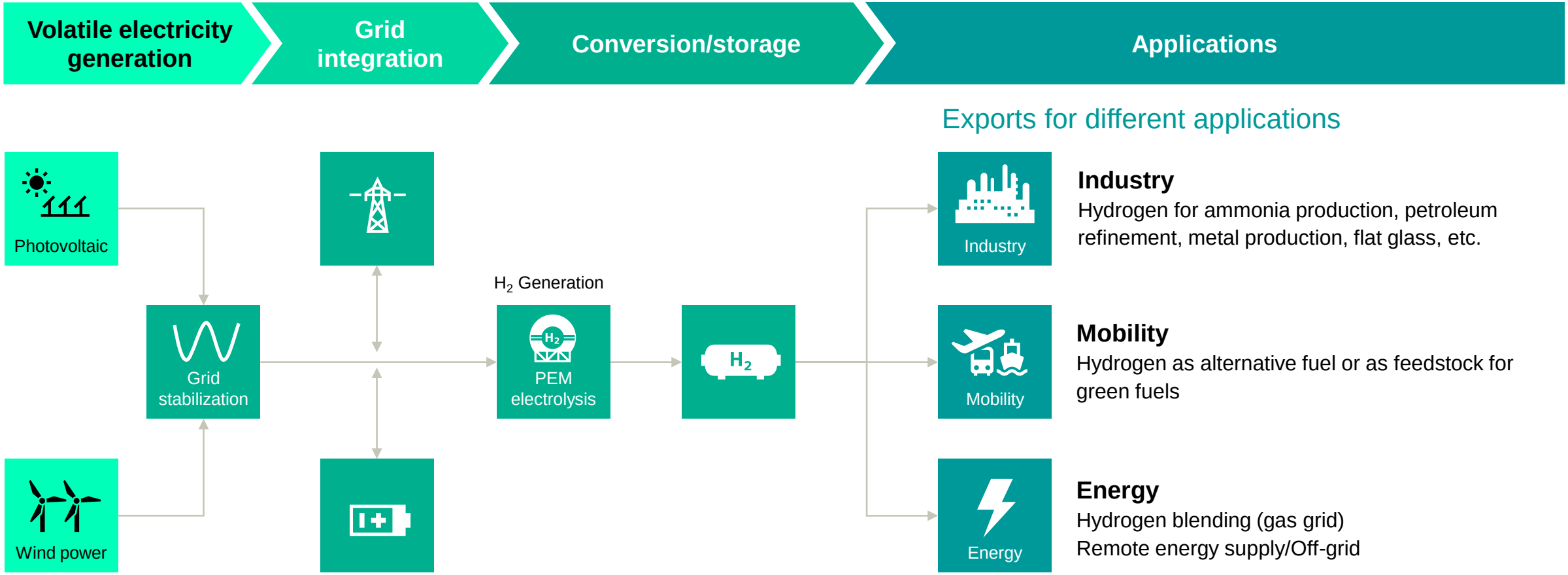
1

Hydrogen is multi-functional – it connects Energy, Mobility and Industry



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Smart electrification covering reliable, safe and efficient power supply with a focus on decarbonization

There are different applications for green hydrogen in Industry, Mobility and Energy

Segment	Application	Description
Industry 	• Ammonia production • Petroleum refinement • Metal production • Other industries	**Onsite H_2 production from renewable energy** replacing Steam methane reforming (SMR) or coal gasification or substitute trailers for industrial processes like ammonia production, petroleum refinement, metal production, glass industry, specialty refineries, food & beverage, chemical industry etc.
Mobility	• Alternative fuel	Using hydrogen as **fuel for fuel cell vehicles** (FCV) for long distance in parallel to BEV for short to medium distance; **Reduction of CO_2 footprint** for individual, public and commercial transport
	• Green fuels	Using hydrogen to create **green fuels** (hydrocarbon mixtures) **substituting or adding to fossil sources of power** (e.g., like 1st/2nd gen biofuels being added to gasoline)
Energy 	• Hydrogen blending (gas grid) • Re-electrification	**Substitute up to 10% Methane/NG** in the gas grid by feeding in hydrogen **Provide energy by re-electrification** of green H_2 (supplied by trailer or produced onsite) in **remote/off-grid areas and/or** substitution of **diesel generators and batteries**
Add on 	• Grid services • Energy storage • Energy export	Using **electrolysis as load** to provide primary and secondary **control power** **Absorb peak production** by storing renewable energy as H_2 **instead of curtailment** **Export** renewable energy with liquid H_2; Ammonia or other hydrogen carrier (e.g. LOHC, LH_2)

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Hydrogen production and usage – today and in the future

New technologies and surplus of renewables will boost usage

Today

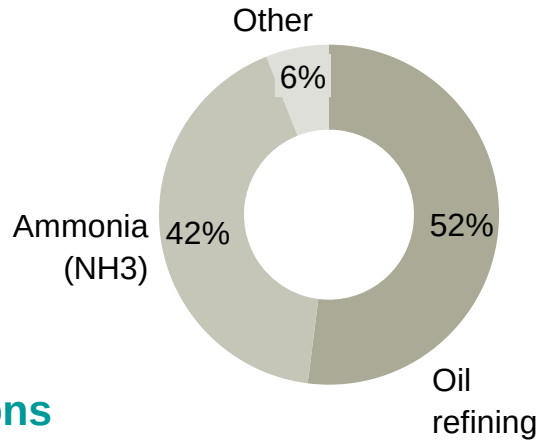
Production

- 75% via **steam reforming** of **natural gas**
  →1 ton H_2 produces 9 tons CO_2!
- 23% via **coal gasification**
  → 1 ton H_2 produces 19 tons CO_2!
- 2% via water electrolysis
  → 1 ton H_2 produces 12 tons CO_2 with fossil power sources

Usage

Primarily used as feedstock in
- **Refineries**
- **Ammonia plants** (for fertilizers)

Other: Glass production, F&B (edible oils), …



Current global Hydrogen demand (2020): 80 million tons

Source: HSBC Global Research “Spotlight Global Hydrogen”, January 2020

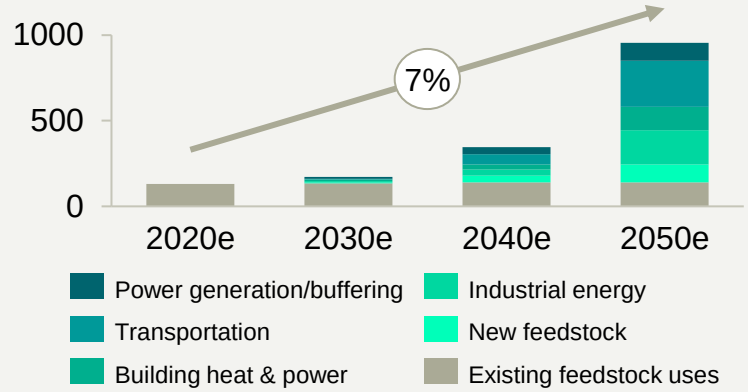
Future

Production

- **Water electrolysis** with renewable power (solar, wind)
  - Alkaline → proven
  - Proton Exchange Membrane (PEM) → New, flexible
  - Solid Oxide Electrolyzer (SOE) → Early stage
- **Methane pyrolysis** (no CO_2) → Early stage

Usage

- **Power storage** (renewable energy surplus)
- **Fuel for transportation** (trucks, cars, trains, ships, aviation)
- **Heat** and **power** for **industrial processes** and **buildings**



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Demand flexibility – Grid interactive efficient infrastructure

Future proofing your infrastructure as environmental regulations become stricter

Generate and store own green power
Generate cost-effective and reliable power onsite

Increase trading success
Sell capacities on all markets. Trading of idle capacities and flexibilities from distributed generation and loads of C&I customers

Complement grid control system
Full workflow from forecasting to financial view

Monitoring and supervising
Power monitoring system for transparent energy flows in buildings

Energy efficiency
Manage energy consumption through facility improvement and building performance optimization measures

Advanced building technologies
including heating, ventilating, and air-conditioning (HVAC) controls, connected lighting, dynamic windows

Electric vehicle charging
Meet the needs of all transportation modes by implementing vehicle charging management solutions

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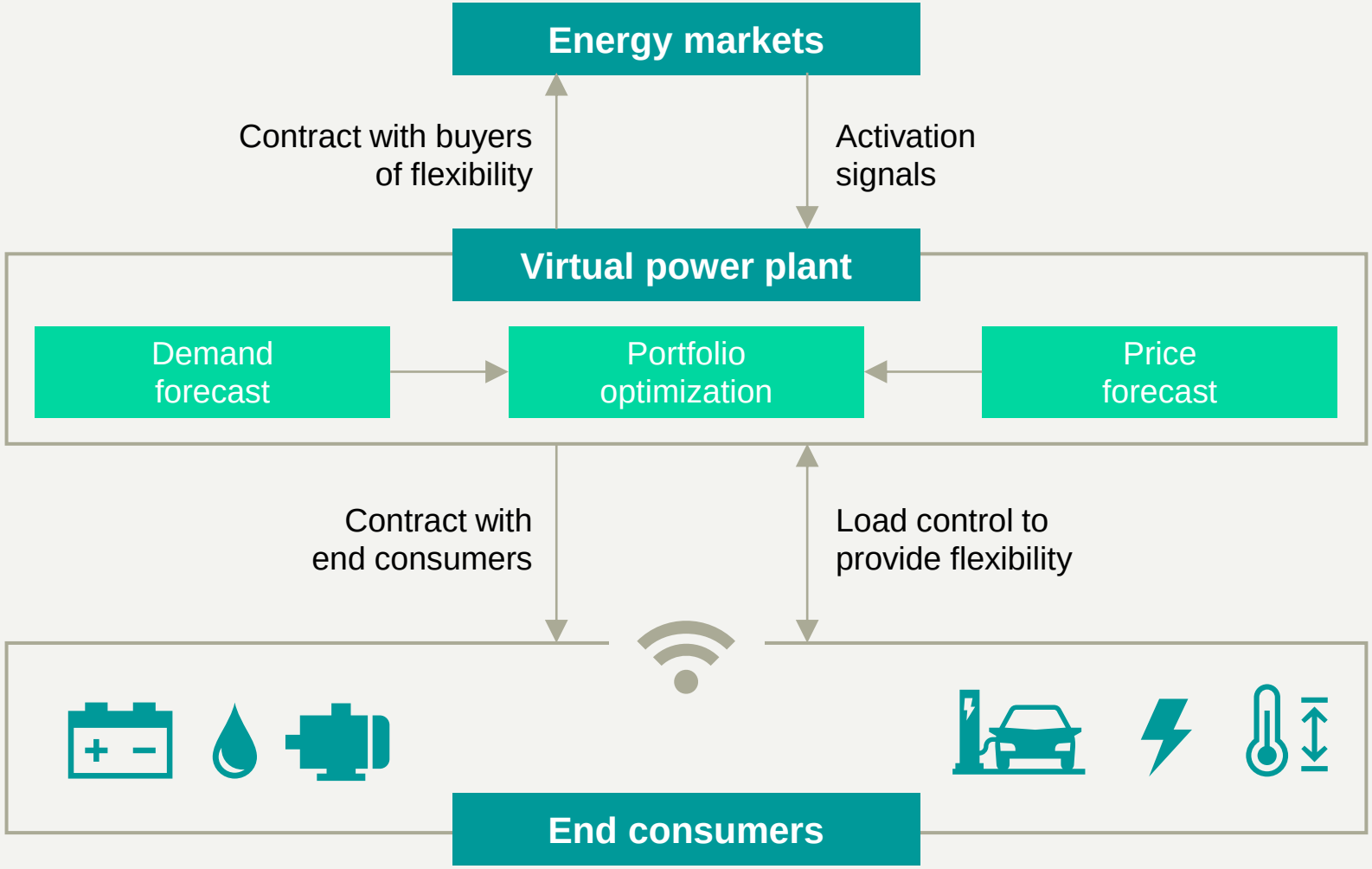
3

Virtual power plants



Virtual power plants

are platforms that act as inter-mediaries between consumers, who have flexible energy loads and network operators.

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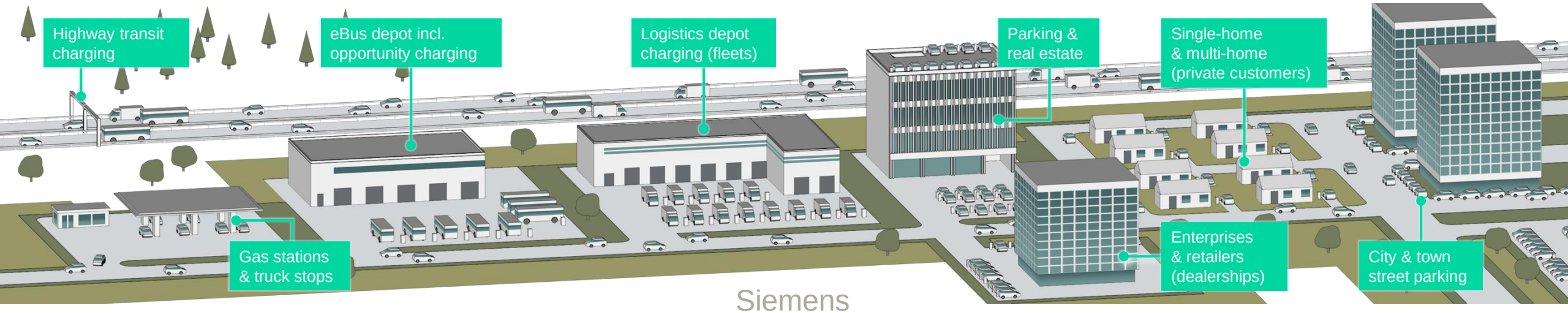
Electrification – The move towards electrification of heat and transport, that adds further flexible electrical loads in the system



Infrastructure enablement

E-vehicle charging incl. product, systems' software, integration & operation

Distributed energy systems: Storage and micro grid/Energie Management Systems

DES

Grid connection and integration in existing power supply architecture

Connection to different Mobility Service providers for eRoaming (public charging)

Siemens eCharging Ecosystem

Services and consulting

eMobility infrastructure consulting & financing

Planning & simulation, engineering

Project management, installation & commissioning

Managed-services, charge point operation & Mobility service provider solutions

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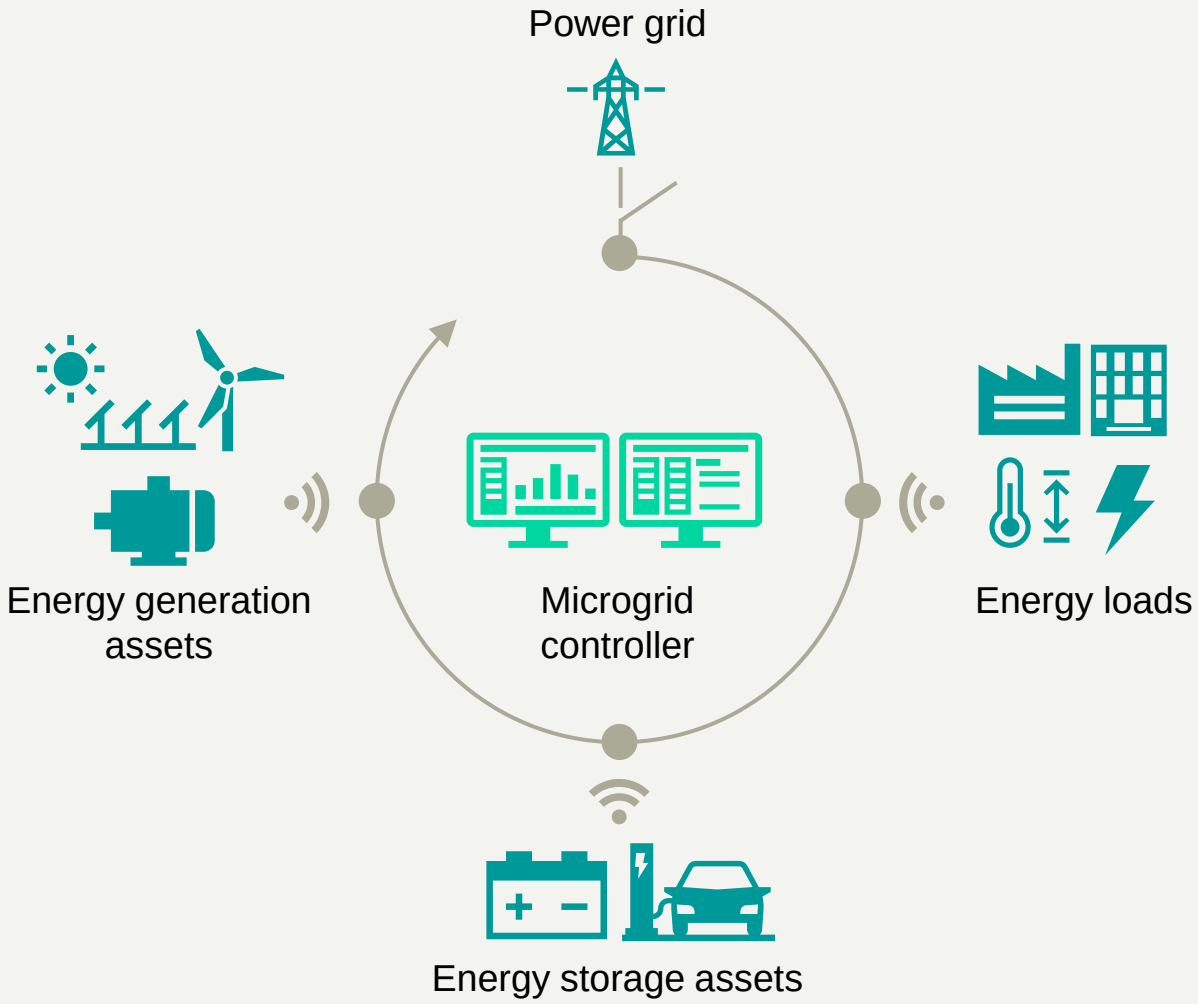
Digitalization



Digitalization

is a key element of the new energy system

Usecase: Digitalization enabling microgrids – microgrids have the potential to reduce the overall CO_2 content of the energy supply.

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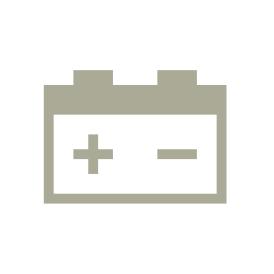
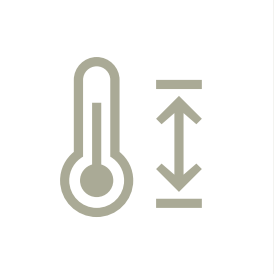
Storage

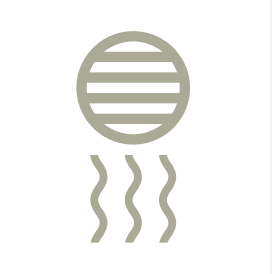


Electrical energy storage

Cold and hot water thermal storage



Phase change thermal storage



Compressed air system

Often own-generated renewable energy is not entirely used if available in abundance. Therefore, also the operation and utilization of generation assets is not optimal.

Storage

Store your excess energy to save costs and reduce your CO_2 footprint

- Operate your assets at optimum performance level
- Increase asset utilization
- Effectively use primary energy resources
- Avoid energy dumping

Battery storage has significant potential in energy management; it can balance intermittent renewable power, smooth out grid frequency and enable firms to be more flexible in their energy purchasing.

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Decarbonization

Financing and investment climate

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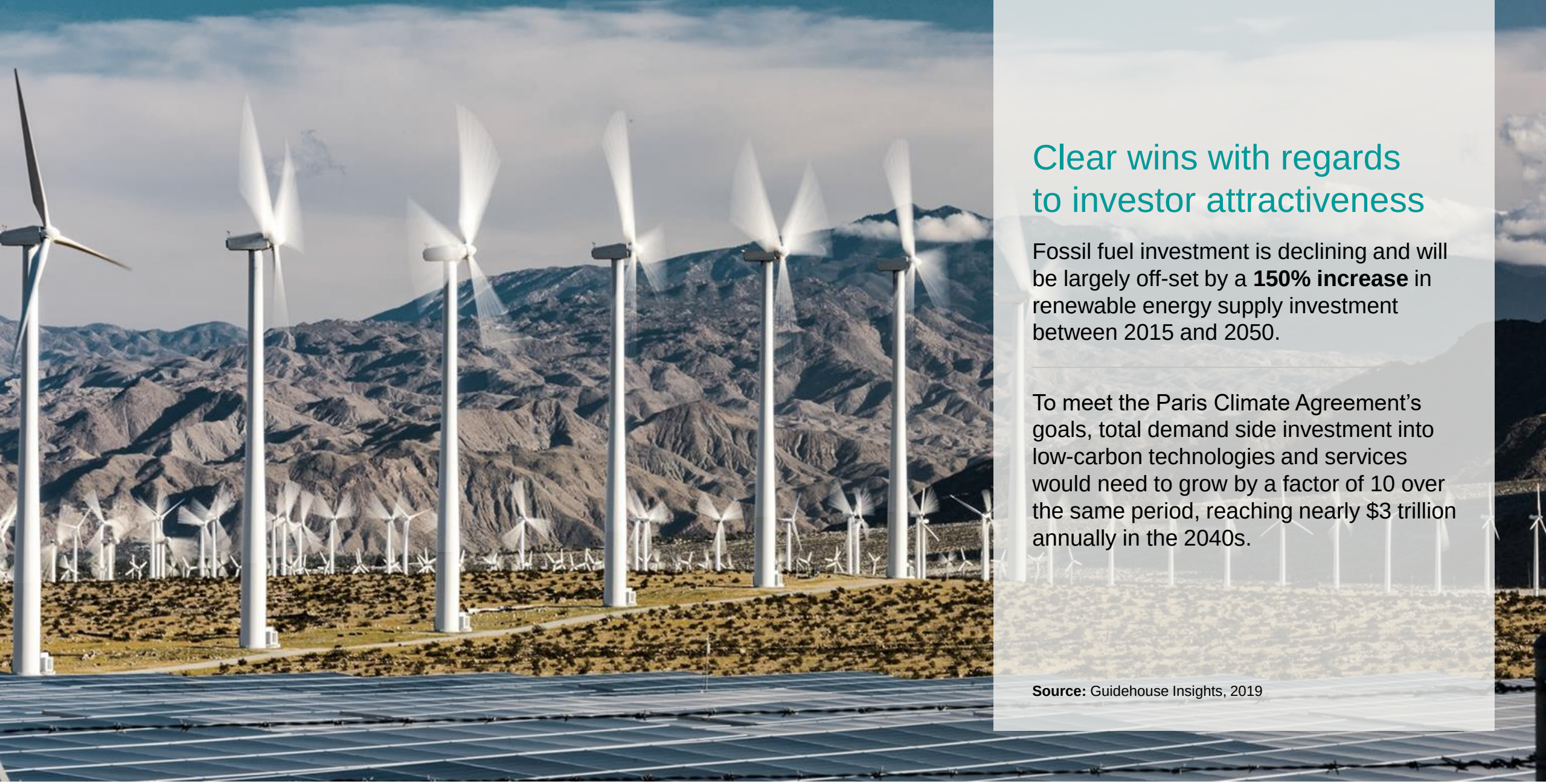

Clear wins with regards to investor attractiveness

Fossil fuel investment is declining and will be largely off-set by a **150% increase** in renewable energy supply investment between 2015 and 2050.

To meet the Paris Climate Agreement's goals, total demand side investment into low-carbon technologies and services would need to grow by a factor of 10 over the same period, reaching nearly $3 trillion annually in the 2040s.

Source: Guidehouse Insights, 2019

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References

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Municipalities & utilities
Comprehensive energy supply, Germany

Customer: SWW Wunsiedel GmbH

Highlights: With a regional and sustainable energy supply based on its “WUNsiedler Weg – Energie” initiative, the public utility in Wunsiedel, Upper Franconia, takes an innovative approach to energy of the future

Challenges/initial situation/customer objectives

Joint realization and implementation of customer roadmap “WUNsiedler Weg – Energie” in the following areas

- Renewable energies (wind, PV, biomass)
- Storage solutions (primary operating reserve, black start capability)
- Energy efficiency (power station internal load optimization in the municipal environment)
- IoT platform for sector coupling

Solution/portfolio

Implement customer roadmap “WUNsiedler Weg – Energie” including, among others:

- Implementation of central and decentralized storage solutions
- Introduction of a system-wide IoT platform based on MindSphere
- Support in implementing eMobility through use of charging infrastructures

Benefits/value to customer

- Comprehensive support and one-face-to-the customer
- Pioneering role in implementing the energy transition
- Continuous strategic planning for further optimizations (examples: Power-to-gas, eMobility integration, distribution grid 4.0)

2016 Technology partnership

24/7 IoT platform for sector coupling

2030 County goal: CO_2-neutrality

Wunsiedel, Germany

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SWW Wundsiedel GmbH

The Wunsiedel way – a blueprint for the energy future

Our customer SWW Wunsiedel GmbH, a publicly-owned, local utility, aims to turn its supply area into an independent system sourced entirely from renewable energy. On their journey to an integrated, distributed supply network, they have teamed up with Siemens in 2016.

The initial focus will be on power and heat generation, storage, control & protection systems, energy efficiency and IoT. Next up is a green hydrogen plant, currently under construction with a capacity of up to 1,350 t green H2.

27,300 t

CO_2 reduction per year

14.6 GWh

additional green energy grid feedback

100%

supply through renewable energy by 2030

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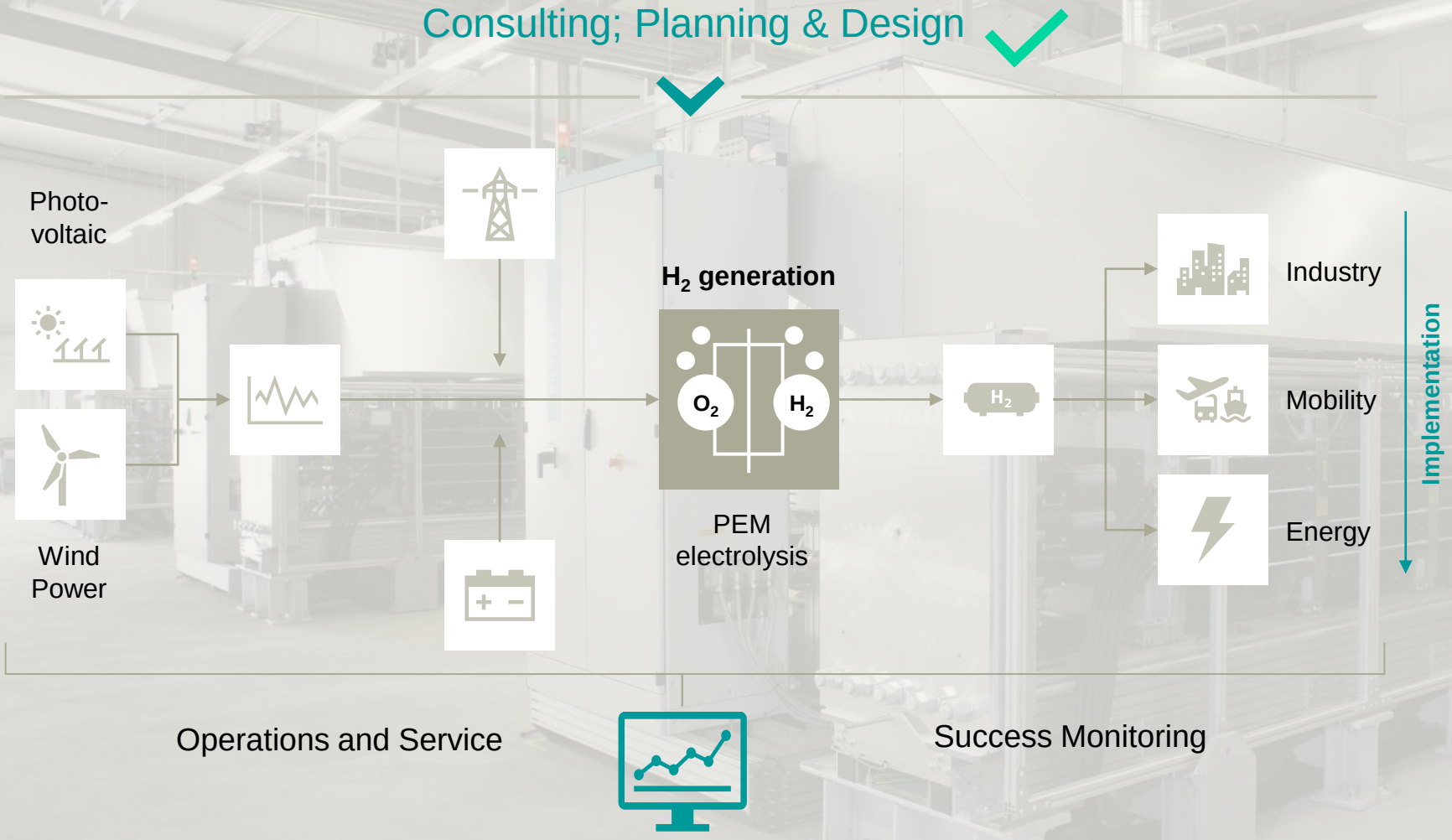
Improve your sustainability through conversion of excess renewable power to hydrogen



- Reach decarbonization goals
- Avoid CO_2 emissions and costs
- Minimize dependency and generate additional revenues through grid support
- Reduce H_2 costs through local hydrogen supply
- Use surplus green energy

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Use Case Stadtwerke Wunsiedel, Germany

Siemens as supplier, partner and operator leveraging hydrogen and all the by-products

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Why Siemens?

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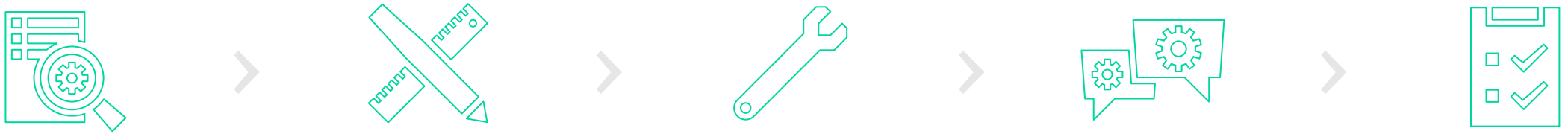
Why Siemens?

We are your partner throughout the entire life cycle – Our approach is unique

For us, your goals and requirements regarding energy and sustainability are in the focus of each of our projects.



Consulting

- Basis of each successful energy project
- Technology independent and competent
- CO_2 Roadmap
- Prioritization of measures
- Budgeting

Planning & Design

- Profound know-how
- Across all trades
- Basis for successful project implementation
- Planning and calculation measures from preliminary studies

Implementation

- Turnkey implementation of the customized project with the involvement of the project management on the customer side
- Coordination of all disciplines
- Siemens portfolio, partners‘ services

Operation & Service

- From conventional maintenance up to technical operating services onsite
- Digital services
- Digital Twin
- Performance review
- Cloud Services
- Ongoing optimization

Success monitoring

- Monitoring of saving and performance goals
- Detecting deviations, correcting proactively
- High comfort and product quality
- Monitor and validate
- Asset monitoring

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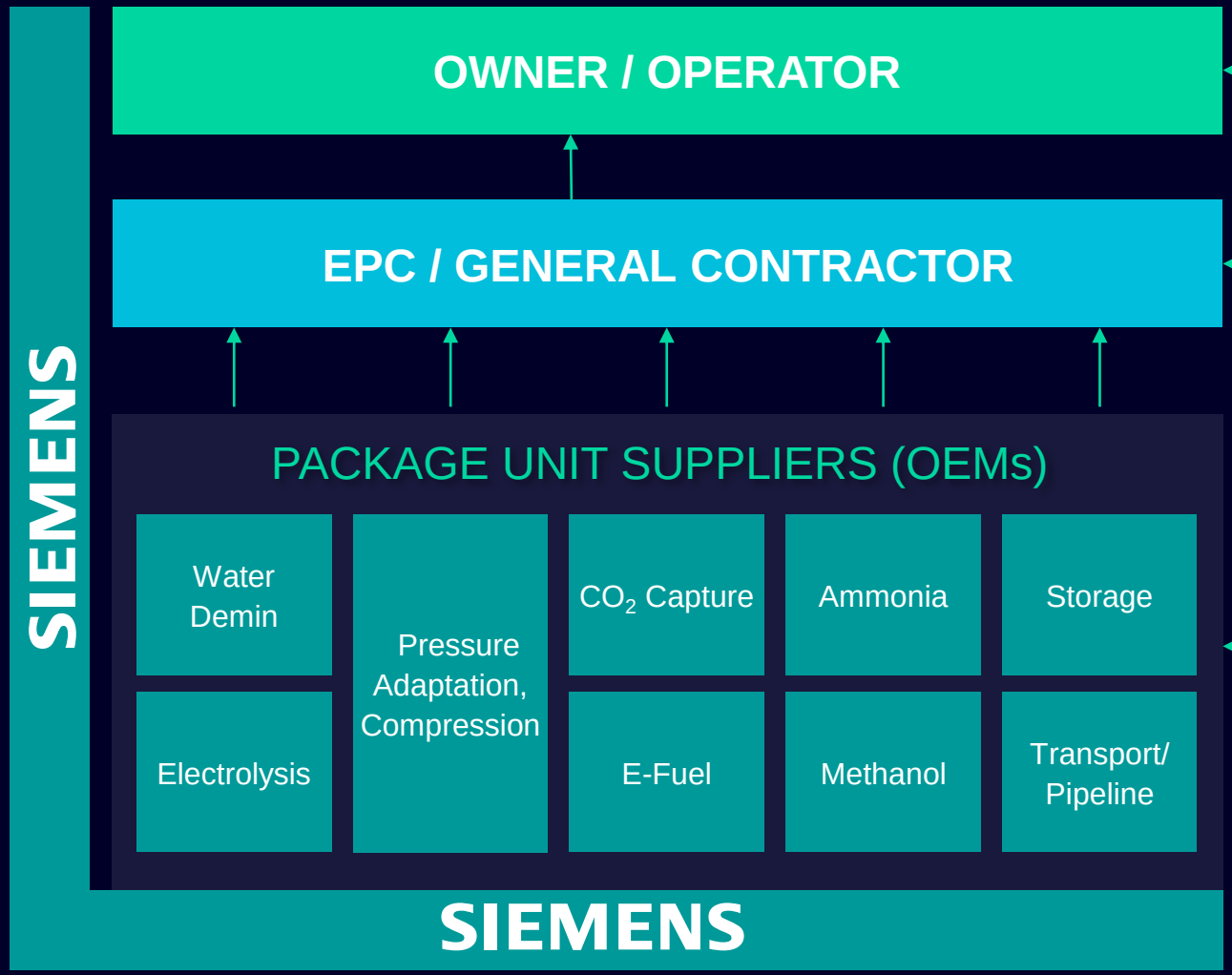
Siemens Portfolio for the Hydrogen Economy
Well-suited on all levels



- Electrification: LV / MV distribution
- Overarching automation systems (DCS or SCADA)
- Cyber security
- Virtual commissioning / Operator Training Systems
- Digital solutions for operations and maintenance (Digital Worker, Digital Logistics)

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- Simulation
- Engineering
- Commissioning / Operator Training Systems
- Automation (DCS or SCADA)
- Gas analyzers (e.g. H_2, O_2 purity)
- Transmitter/sensors (pressure, temperature, flow, level)
- Valve positioners
- Rectifiers for electrolyzers
- Motors und drives
- Remote maintenance, telecontrol

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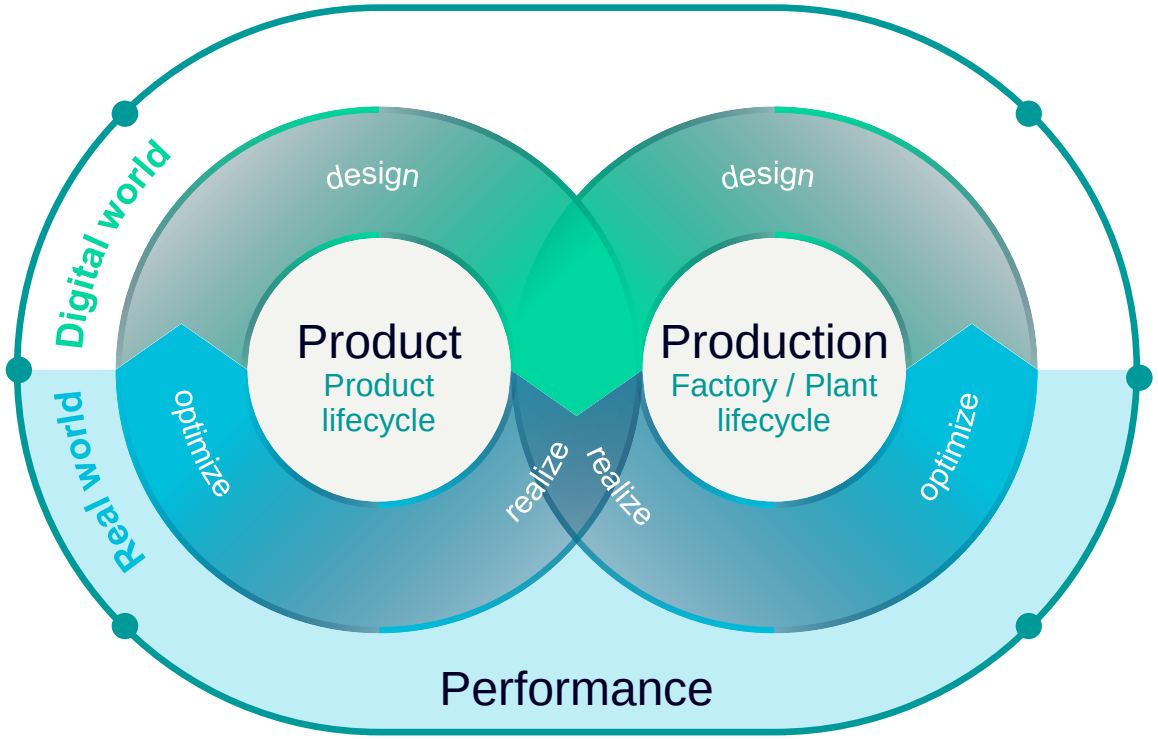
Benefiting from a comprehensive Digital Twin approach



Digital twin product: A **digital twin** completely represents the physical item and creates a huge sustainability advantage over physical **products**, costly prototyping and the cost of design changes historically done manually. In combination with innovative production technologies such as additive manufacturing, this **saves up to 50% of material**.

Digital twin production: With **digitally optimized production processes**, data analysis and virtual commissioning, and with innovative, integrated drive technologies, customers can **save up to 40% energy** and the corresponding amount of **CO_2 emissions**.

Digital twin performance: By monitoring the **performance** of products and processes and **feeding the data back** into product design and production planning, the consumption of resources and the ecological footprint of products are constantly optimized across the entire lifecycle.

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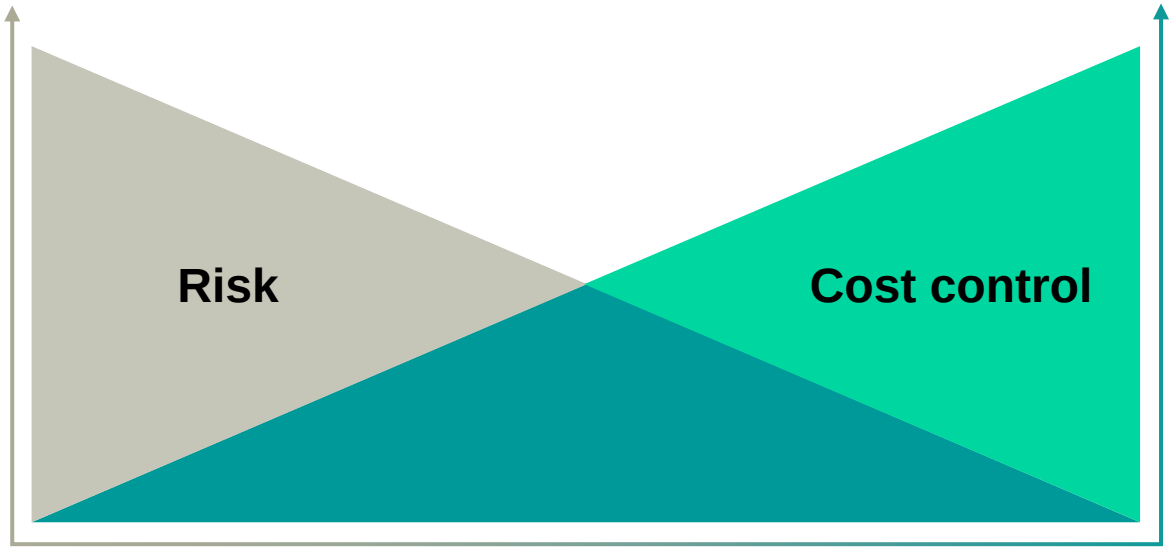
Minimize your risk and take control over lifecycle costs

With customized business and delivery models

Turnkey/ EPC Project	Pay-as-you-save and Performance Guarantee	Efficiency as a Service	Energy as a Service



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